Tattoo Recognition Technology - Challenge (Tatt-C)
Dataset, Concept, and Evaluation Plan
Version 1.4

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Timeline of the Tatt-C

Phase	Date	Milestone
Announcement	2014-07-24	Website up, announce activity
Participation Period	2014-09-23	Tatt-C participation window opens; Dataset available for participants
	2015-02-06	Deadline for submission of Phase 1 results from participants
	2015-05-04	Deadline for submission of Phase 2 results from participants; Tatt-C participation window closes
Workshop	2015-06-01	Deadline for registration to attend Tatt-C workshop; Deadline for participant registration to present at Tatt-C workshop
	2015-06-08	Tatt-C workshop at NIST
Ongoing Participation	Ongoing	The Tatt-C dataset is available for researchers on an ongoing basis, and results submissions will be accepted by NIST on a continuous basis.

Acknowledgements

The organizers would like to thank the sponsor of this activity, the Federal Bureau of Investigation (FBI) Biometric Center of Excellence (BCOE) for initiating and progressing this work. In addition, we would like to thank the FBI Cryptanalysis and Racketeering Records Unit (CRRU), Department of Defense (DoD) Defense Forensics and Biometrics Agency (DFBA), Department of Justice (DOJ) National Institute of Justice (NIJ), and the MITRE Corporation for their support and contributions.

Contact Information

Email: tattoo@nist.gov

Tatt-C Website: http://www.nist.gov/itl/iad/ig/tatt-c.cfm

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1. Background

Tattoos have been used for many years to assist law enforcement in the identification of criminals and victims and for investigative research purposes.* Historically, law enforcement agencies have followed the ANSI/NIST-ITL 1-2011[1] standard to collect and assign keyword labels to tattoos. This keyword labeling approach comes with drawbacks, which include the limitation of ANSI/NIST standard class labels to describe the increasing variety of new tattoo designs, the need for multiple keywords to sufficiently describe some tattoos, and subjectivity in human annotation as the same tattoo can be labeled differently between examiners. As such, the shortcomings of keyword-based tattoo image retrieval have driven the need for automated image-based tattoo recognition capabilities.

2. Scope

The Tattoo Recognition Technology - Challenge (Tatt-C) is a challenge to academic and commercial developers to advance automated image-based tattoo matching technology. The activity will drive and assess the capability of image-based tattoo recognition methods to detect and retrieve tattoos, with the goals to determine which are most effective and whether they are viable for the following operational use-cases:

- Tattoo Similarity - matching visually similar or related tattoos from different subjects
- Tattoo Identification - matching different instances of the same tattoo image from the same subject over time
- Region of Interest - matching a small region of interest that is contained in a larger image
- Mixed Media - matching visually similar or related tattoos using different types of images (e.g., sketches, scanned print, computer graphics, or natural images)
- Tattoo Detection - detecting whether an image contains a tattoo or not

This document establishes the protocol that participants should follow for the Tatt-C activity, which includes detailed information regarding the dataset, the challenges and the output format for self-reporting back to NIST, and accuracy metrics used to assess performance. Any questions or clarifications regarding this document should be sent to tattoo@nist.gov.

3. Audience

Universities and commercial entities with capabilities in detection and/or matching of tattoos or other unconstrained images are invited to participate in the Tatt-C challenge. Organizations will need to follow the protocol detailed in this document. Participation is open worldwide. There is no charge for participation.

4. Procedures

This section outlines the steps that should be followed by Tatt-C participants. Please feel free to contact NIST at tattoo@nist.gov with inquiries regarding Tatt-C.

OBTAIN THE DATASET

- Fill out the Tatt-C Data Request Form available from the Tatt-C website: http://www.nist.gov/itl/iad/ig/tatt-c.cfm and email it to tattc_dataset@nist.gov.
- After receipt of the request form, the submitter will receive, via email, a data release document that will need to be signed and further instructions on obtaining the dataset will be provided.

LOCATE DATA FOR EACH TEST CASE

- The Tatt-C distribution has the data split out by use case, that is, into the following folders - **tattoo_similarity/**, **tattoo_identification/**, **region_of_interest/**, **mixed_media/**, and **tattoo_detection/**.

RUN ALGORITHM ON TEST CASES

[1] The latest version of the ANSI/NIST-ITL 1-2011 standard is available at http://www.nist.gov/itl/iad/ig/ansi_standard.cfm.
* A sentence was removed on May 19, 2016 based on feedback we received which indicated that the previous text did not accurately convey the intent of the project.

- Section 7 specifies the test protocol and list of test cases and for each test case, the images and actions required to generate an output file in the specified format (i.e. a Candidate List or Classification List). Output files shall be named according to the naming convention specified in Section 8.4.

SUBMIT RESULTS TO NIST

- Per the guidelines for participation in Section 5, participants may choose to work on and submit results for one or more test cases. Participants are encouraged to develop and run their algorithms on all test cases.
- Participants should send their results in the form of Candidate Lists and/or Classification Lists to NIST. NIST will engage interested participants in discussions to help support and progress development.
- Participants can either email the files to tattoo@nist.gov or put the files onto electronic media (e.g., CD, USB drive) and mail it to NIST. NIST's mailing address is provided in Section 11.

5. Guidelines for participation

The following guidelines apply:

- A participant must properly submit a data request and sign a data release agreement to obtain the dataset (see Section 4).
- Participants are not required to submit results for all test cases (see Table 4 for the list of test cases), but are highly encouraged to develop and run their algorithms on all test cases.

6. Tatt-C Dataset

The dataset includes partitions that are representative of operational use cases for tattoo detection and matching.

Table 1 – Use Cases supported under Tatt-C

	Tattoo Similarity	Tattoo Identification	Region of Interest	Mixed Media	Tattoo Detection
Use case	Match visually similar or related tattoos from different subjects	Match different instances of the same tattoo from the same subject over time	Match small region of interest contained in a larger tattoo	Match visually similar or related tattoos across different mediums	Detect whether an image contains a tattoo
Utility Example	Gang* Affiliation	Person Identification	Person Identification	Intelligence Gathering	Database construction and maintenance
Task	One-to-many search	One-to-many search	One-to-many search	One-to-many search	Classification
Types of images	Tattoos	Tattoos	Tattoos	Tattoos, sketches, computer graphics, graffiti	Tattoos, faces[2]
Folder name	tattoo_similarity	tattoo_identification	region_of_interest	mixed_media	tattoo_detection
Total number of images	2212	372	454	453	2349
Compression	JPEG, quality on [50, 100]				
File size	Min: 0.8 kilobytes; Max: 2.7 megabytes				

[2] Historically, scars, marks, and tattoo (SMT) images collected by law enforcement are stored in the ANSI/NIST-ITL 1-2011 Type 10 record. The Type 10 record is also used to store facial mug shot images, and as a result, face and tattoo images are often comingled, with a percentage of the data mislabeled or not labeled, making automated extraction of face versus tattoo data a challenge. Face images in the dataset were extracted from the public NIST Special Database 32 - Multiple Encounter Database (MEDS), available at: http://www.nist.gov/itl/iad/ig/sd32.cfm.

* This phrase was modified on May 19, 2016 based on feedback we received which indicated that the previous text did not accurately convey the intent of the project.

In the data distribution, there is a folder for each use case that contains images along with ground truth and metadata files. The following sections describe the contents of each folder in more detail.

Unless otherwise specified, all text files with multiple fields are pipe (i.e. |) delimited.

6.1 Test

For each use case, there is a **test**/ folder that contains the following content:

Table 2 – Test folder content

Folder or File	Content	Notes
images/	Contains images	There are some use cases that will have an **orig/** folder and a **cropped/** folder. The **orig/** folder contains the original image from collection. The **cropped/** folder contains cropped versions of the images based on the bounding box coordinates around the tattoo content provided in the metadata.txt file (See Section 6.2). For images where the bounding box coordinates were not available, the original image size was used.
metadata.txt	Metadata for all images (see Section 6.2 for more detail)	
ground_truth.txt	Ground truth information for the images (see Section 6.3 for file formats)	
probes_*.txt	One or more files containing probe images to test	Each probe file will support one or more test cases (see Section 7 for test cases)
gallery_*.txt	One or more files containing gallery images to enroll	Each gallery file will support one or more test cases (see Section 7 for test cases). The tattoo_detection test folder does not contain any gallery files as the test case represents a classification task that doesn't require enrollment of images.

6.2 Metadata

Within the **test/** folder, there is a metadata.txt file that contains image names and any corresponding metadata (if available) in the format specified in Table 3. A number of the fields are derived from the Type 10 record of the ANSI/NIST-ITL 1-2011 standard.

Table 3 – Metadata

Field Name	Description	Notes
img_name	Name of the image	
ansi_nist_class	ANSI/NIST-ITL 1-2011 Type 10 Tattoo class and subclass codes	This field contains the general class code and subclass code chosen from the 8 class codes and 70 subclass codes specified in the ANSI/NIST-ITL 1-2011 standard. See Appendix A.1 for the class and subclass codes.
description	ANSI/NIST-ITL 1-2011 Type 10 Tattoo description	This is a free-text field that provides additional qualifiers to describe the image.
color	ANSI/NIST-ITL 1-2011 Type 10 Tattoo color	This field specifies the color(s) of the tattoo as specified by the ANSI/NIST-ITL 1-2011 standard. See Appendix A.2 for the list of color codes.
body_location	ANSI/NIST-ITL 1-2011 Type 10 NCIC SMT code for body location	This field specifies a general location of the tattoo as specified by the ANSI/NIST-ITL 1-2011 standard, referencing the National Crime Information Center (NCIC) SMT Body Location Codes. See Appendix B.1 for the list of body location codes.
rect_coordinates(x,y,width,height)	Coordinates for bounding box drawn around tattoo content	The format of the bounding box coordinates in the metadata file is x, y, width, height.
orientation	Orientation specification of the tattoo image	This is based on a 360 degree scale, with true north=0 degrees. For example, orientation=30 means the tattoo is rotated 30 degrees clockwise.

Please note that not all images have metadata information available.

6.3 Ground Truth

Within the **test/** folder, there is a ground_truth.txt file that contains the mapping between relevant images that should be correctly matched in a one-to-many search or, for the tattoo detection use case, whether the image contains a tattoo or not. The file will be in the following format.

6.3.1 Probe and Gallery Format

This file format contains the ground truth mapping between the probe images and their matching gallery images. There is one probe and gallery image pair per line. There can be more than one matching gallery image per probe image; in those cases, the same probe image with a different gallery name is listed on a separate line.

6.4 Background Images

The **background/** folder contains 4332 images that will be used for adding to the enrollment gallery for various test cases.

7. Testing

7.1 Protocol

To generate performance results, participants should follow a 5-fold cross validation scheme with the splits provided in the Tatt-C distribution. For each use case, the images are randomly split into 5 subsets. The images in each subset are mutually exclusive, so there are no overlapping images between the subsets. Using this split, performance results should be produced using 5-fold cross validation. That is, for each test case specified in Table 4, participants should conduct 5 separate experiments in a leave-one-out cross validation scheme. In each experiment, 4 of the subsets should be combined to form a training set, with the 5th subset used for testing. For example, the first experiment would use subsets (2, 3, 4, 5) for training and subset 1 for testing. The 4th experiment would use subsets (1, 2, 3, 5) for training and subset 4 for testing. Participants should submit the output of all 5 experiments to NIST. The output format is specified in Table 8.

Algorithm parameters under each experiment should be set using only the training data for that experiment to avoid fitting to the test data. In other words, each of the 5 experiments (both the training and test phases) should be run completely independently of the others.

7.2 Outside Training Data

The use of data outside of the Tatt-C dataset for algorithm development/training is allowed. Participants are required to disclose whether outside training data was used when they submit their results to NIST.

7.3 Test Cases

The following table specifies the test cases to be executed. The expected output format is given in Section 8. For test cases where "no metadata utilization" is specified, participants shall not utilize metadata.txt to support their algorithm. For test cases that specify that image metadata usage is allowed, developers may use the metadata however they see fit to support their algorithms. Note: For use cases that have both original and cropped versions of the images, they will be located under the images/orig and images/cropped folders respectively. For use cases that do not have cropped versions of the images, the original images will just be located under the images/ folder.

Table 4 – Test Cases

Number	Test case	Images	1. Enrollment	2. Search/Classification	3. Output
SIM-1	Tattoo Similarity - original images, small gallery, no metadata utilization	Original versions of probe and gallery images	For each fold, enroll images listed in tattoo_similarity/gallery{n}.txt	For each fold, search on images listed in tattoo_similarity/probes{n}.txt	Candidate List (see Section 8.1)

SIM-2	Tattoo Similarity - original images, larger gallery, no metadata utilization	Original versions of probe and gallery images + original versions of background images	For each fold, enroll images listed in tattoo_similarity/gallery{n}.txt PLUS background/bg.txt.	For each fold, search on images listed in tattoo_similarity/probes{n}.txt	
SIM-1-CR	Tattoo Similarity - cropped probe and gallery images, small gallery, no metadata utilization	Cropped versions of probe and gallery images	For each fold, enroll images listed in tattoo_similarity/gallery{n}.txt	For each fold, search on images listed in tattoo_similarity/probes{n}.txt	
SIM-2-CR	Tattoo Similarity – cropped probe and gallery images, larger gallery, no metadata utilization	Cropped versions of probe and gallery images + cropped versions of background images	For each fold, enroll images listed in tattoo_similarity/gallery{n}.txt PLUS background/bg.txt.	For each fold, search on images listed in tattoo_similarity/probes{n}.txt	
SIM-1-CR-PROBES	Tattoo Similarity - cropped probe images, small gallery, no metadata utilization	Cropped versions of probe images and original versions of the gallery images	For each fold, enroll images listed in tattoo_similarity/gallery{n}.txt	For each fold, search on images listed in tattoo_similarity/probes{n}.txt	
SIM-2-CR-PROBES	Tattoo Similarity – cropped probe images, larger gallery, no metadata utilization	Cropped versions of probe images, original versions of the gallery images + original versions of background images	For each fold, enroll images listed in tattoo_similarity/gallery{n}.txt PLUS background/bg.txt.	For each fold, search on images listed in tattoo_similarity/probes{n}.txt	
ID-1	Tattoo Identification - small gallery, no metadata utilization	Original versions of probe and gallery images	For each fold, enroll images listed in tattoo_identification/gallery{n}.txt	For each fold, search on images listed in tattoo_identification/probes{n}.txt	
ID-2	Tattoo Identification - larger gallery, no metadata utilization	Original versions of probe and gallery images + cropped versions of background images	For each fold, enroll images listed in tattoo_identification/gallery{n}.txt PLUS background/bg.txt.	For each fold, search on images listed in tattoo_identification/probes{n}.txt	
ROI-1	Region of Interest - small gallery, no metadata utilization	Original versions of probe and gallery images	For each fold, enroll images listed in region_of_interest/gallery{n}.txt	For each fold, search on images listed in region_of_interest/probes{n}.txt	
ROI-2	Region of Interest - larger gallery, no metadata utilization	Original versions of probe and gallery images + cropped versions of background images	For each fold, enroll images listed in region_of_interest/gallery{n}.txt PLUS background/bg.txt.	For each fold, search on images listed in region_of_interest/probes{n}.txt	
MM-1	Mixed Media - small gallery, no metadata utilization	Original versions of probe and gallery images	For each fold, enroll images listed in mixed_media/gallery{n}.txt	For each fold, search on images listed in mixed_media/probes{n}.txt	
MM-2	Mixed Media - larger gallery, no metadata utilization	Original versions of probe and gallery images + original versions of background images	For each fold, enroll images listed in mixed_media/gallery{n}.txt PLUS background/bg.txt.	For each fold, search on images listed in mixed_media/probes{n}.txt	
DET-1	Tattoo Detection, no metadata utilization			For each fold, classify whether images contain a tattoo or not for all images in tattoo_detection/probes{n}.txt	Classification List (see Section 8.2)
SIM-1-META	Same as SIM-1 plus the use of any available image metadata from metadata.txt is allowed.				

SIM-2-META	Same as SIM-2 plus the use of any available image metadata from metadata.txt is allowed.
SIM-1-CR-META	Same as SIM-1-CR plus the use of any available image metadata from metadata.txt is allowed.
SIM-2-CR-META	Same as SIM-2-CR plus the use of any available image metadata from metadata.txt is allowed.
SIM-1-CR-PROBES-META	Same as SIM-1-CR-PROBES plus the use of any available image metadata from metadata.txt is allowed.
SIM-2-CR-PROBES-META	Same as SIM-2-CR-PROBES plus the use of any available image metadata from metadata.txt is allowed.
ID-1-META	Same as ID-1 plus the use of any available image metadata from metadata.txt is allowed.
ID-2-META	Same as ID-2 plus the use of any available image metadata from metadata.txt is allowed.
ROI-1-META	Same as ROI-1 plus the use of any available image metadata from metadata.txt is allowed.
ROI-2-META	Same as ROI-2 plus the use of any available image metadata from metadata.txt is allowed.
MM-1-META	Same as MM-1 plus the use of any available image metadata from metadata.txt is allowed.
MM-2-META	Same as MM-2 plus the use of any available image metadata from metadata.txt is allowed.

8. Output of Results

This section describes the fields and format of the output files. Samples of the output files in the specified formats are available in the **sample_output/** folder. Note: The format of the output files has been updated. Please see Table 8.

8.1 Candidate List

All searches shall return a candidate list of the entire length of the enrollment gallery[3]. See Table 4 for more detail on the gallery sizes for each test case. The list shall be sorted with the most similar matching entry listed first with lowest rank. The fields shall be pipe (i.e. |) delimited. The format of the candidate list is specified in Table 5.

Table 5 – Candidate List Format

Field name	**probe**	**rank**	**gallery**	**similarity_score**
Datatype	String	Unsigned Integer	String	Unsigned Integer or Float
Description	Name of the probe image	Rank number	Name of the matching gallery image	Measure of similarity between the probe image and the enrolled gallery image. Higher scores denote higher likelihood of similarity.
Example lines of a candidate list up to rank N, for R probes, appear to the right. A complete file will contain NxR lines (excluding the header line).	probe_001.jpg	1	gallery_005.jpg	16383
	probe_001.jpg	2	gallery_007.jpg	9798
	probe_001.jpg	3	gallery_001.jpg	892
	...			
	probe_001.jpg	N	gallery_090.jpg	0
	probe_002.jpg	1	gallery_050.jpg	16111
	probe_002.jpg	2	gallery_061.jpg	12890

[3] If an algorithm natively finds only similar matches and does not produce full length candidate lists, developers should nevertheless populate the remainder of the candidate list, up to rank N, with **gallery="NA"** for unlisted gallery images and **similarity_score="0"**.

In the event an algorithm fails to process P number of probe images, the file will contain (R-P) x N lines. In the event an algorithm fails to process G number of gallery images, the file will contain R x (N-G) lines.	probe_002.jpg	3	gallery_100.jpg	6777
	…			
	probe_002.jpg	N	gallery_062.jpg	0
	…			
	…			
	probe_R.jpg	1	gallery_062.jpg	15000
	…			
	probe_R.jpg	N	gallery_001.jpg	0

8.2 Classification List

All classification tasks shall return a classification list. The fields shall be pipe (i.e. |) delimited. The format of the classification list is specified in Table 6.

Table 6 – Classification List Format

Field name	**img_name**	**classification**	**confidence**
Datatype	String	Unsigned Integer	Float
Description	Name of the image	Classification of whether a tattoo was detected in the image or not. Valid values are: 1: A tattoo was detected in the image 0: A tattoo was not detected in the image	A real-valued measure of tattoo detection confidence on [0,1]. A value of 1 indicates certainty that the image contains a tattoo, and a value of 0 indicates certainty that the image does not contain a tattoo.
Example lines of a classification list for R images appear to the right. Lines 1, 2, 3 and R appear.	img_0001.jpg	1	.9000
	Img_0002.jpg	1	.7812
	img_0003.jpg	0	.0044
	...		
	img_R.jpg	1	1

8.3 Errors

Algorithms may fail to process input images for a number of reasons. For example, the image may be assessed to have insufficient quality from which to extract features. In the event an algorithm fails to process an image, the event shall be logged in an error log in the format specified in Table 7. The fields shall be pipe (i.e. |) delimited.

Table 7 – Error log format

Field name	img_name	description
Datatype	String	String
Description	Name of the image	Free-text description of error
Example lines of an error log	gallery_059.jpg	Unable to extract features
	…	

8.4 File names

The output files for the various test scenarios shall be named according to what is specified in Table 8. The output files should be placed in a folder hierarchy specified as **<organization name>/ongoing/<algorithm number>/** (e.g., MITRE/ongoing/alg1/*.candidate_lists) and archived with a utility such as tar or zip prior to submission to NIST.

Table 8 – Output file names

Number	Test case	Output file name, where {n} is the n^{th} fold of the 5-fold cross validation	Error log name

SIM-1	Tattoo Similarity - original images, small gallery, no metadata utilization	SIM-1_{n}.candidate_lists	SIM-1_{n}.error_log
SIM-2	Tattoo Similarity - original images, larger gallery, no metadata utilization	SIM-2_{n}.candidate_lists	SIM-2_{n}.error_log
SIM-1-CR	Tattoo Similarity - cropped probe and gallery images, small gallery, no metadata utilization	SIM-1-CR_{n}.candidate_lists	SIM-1-CR_{n}.error_log
SIM-2-CR	Tattoo Similarity - cropped probe and gallery images, larger gallery, no metadata utilization	SIM-2-CR_{n}.candidate_lists	SIM-2-CR_{n}.error_log
SIM-1-CR-PROBES	Tattoo Similarity - cropped probe images, small gallery, no metadata utilization	SIM-1-CR-PROBES_{n}.candidate_lists	SIM-1-CR-PROBES_{n}.error_log
SIM-2-CR-PROBES	Tattoo Similarity - cropped probe images, larger gallery, no metadata utilization	SIM-2-CR-PROBES_{n}.candidate_lists	SIM-2-CR-PROBES_{n}.error_log
ID-1	Tattoo Identification - small gallery, no metadata utilization	ID-1_{n}.candidate_lists	ID-1_{n}.error_log
ID-2	Tattoo Identification - larger gallery, no metadata utilization	ID-2_{n}.candidate_lists	ID-2_{n}.error_log
ROI-1	Region of Interest - small gallery, no metadata utilization	ROI-1_{n}.candidate_lists	ROI-1_{n}.error_log
ROI-2	Region of Interest - larger gallery, no metadata utilization	ROI-2_{n}.candidate_lists	ROI-2_{n}.error_log
MM-1	Mixed Media - small gallery, no metadata utilization	MM-1_{n}.candidate_lists	MM-1_{n}.error_log
MM-2	Mixed Media - larger gallery, no metadata utilization	MM-2_{n}.candidate_lists	MM-2_{n}.error_log
DET-1	Tattoo Detection, no metadata utilization	DET-1_{n}.classification_lists	DET-1_{n}.error_log
SIM-1-META	Tattoo Similarity - original images, small gallery, with metadata	SIM-1-META_{n}.candidate_lists	SIM-1-META_{n}.error_log
SIM-2-META	Tattoo Similarity - original images, larger gallery, with metadata	SIM-2-META_{n}.candidate_lists	SIM-2-META_{n}.error_log
SIM-1-CR-META	Tattoo Similarity - cropped probe and gallery images, small gallery, with metadata	SIM-1-CR-META_{n}.candidate_lists	SIM-1-CR-META_{n}.error_log
SIM-2-CR-META	Tattoo Similarity – cropped probe and gallery images, larger gallery, with metadata	SIM-2-CR-META_{n}.candidate_lists	SIM-2-CR-META_{n}.error_log
SIM-1-CR-PROBES-META	Tattoo Similarity – cropped probe images, small gallery, with metadata	SIM-1-CR-PROBES-META_{n}.candidate_lists	SIM-1-CR-PROBES-META_{n}.error_log
SIM-2-CR-PROBES-META	Tattoo Similarity – cropped probe images, larger gallery, with metadata	SIM-2-CR-PROBES-META_{n}.candidate_lists	SIM-2-CR-PROBES-META_{n}.error_log
ID-1-META	Tattoo Identification - small gallery, with metadata	ID-1-META_{n}.candidate_lists	ID-1-META_{n}.error_log
ID-2-META	Tattoo Identification - larger gallery, with metadata	ID-2-META_{n}.candidate_lists	ID-2-META_{n}.error_log
ROI-1-META	Region of Interest - small gallery, with metadata	ROI-1-META_{n}.candidate_lists	ROI-1-META_{n}.error_log
ROI-2-META	Region of Interest - larger gallery, with metadata	ROI-2-META_{n}.candidate_lists	ROI-2-META.error_log
MM-1-META	Mixed Media - small gallery, with metadata	MM-1-META_{n}.candidate_lists	MM-1-META_{n}.error_log
MM-2-META	Mixed Media - larger gallery, with metadata	MM-2-META_{n}.candidate_lists	MM-2-META_{n}.error_log

9. Metrics

This section describes some of the metrics used for measuring match and classification performance. NIST will extend the analysis with other metrics and in response to participant-submitted results. Sample R code for generation of the metrics described in this section is maintained and available for download from the Tatt-C website: http://www.nist.gov/itl/iad/ig/tatt-c.cfm. The sample R code takes an output file (i.e. candidate list or classification list) in the specified format and a ground truth file and generates the metrics described in this section.

9.1 Cumulative Match Characteristic (CMC)

Table 9 – CMC Definition

Use cases	Metric
Tattoo Identification, Region of Interest	CMC = The probability that one or more correct matching image for a probe is observed within the top K ranks.

9.2 Precision and Recall

Table 10 – Confusion Matrix

		Actual	
		Positives	Negatives
Predicted	Positives	**TP (True Positive)** # of relevant images that are correctly retrieved	**FP (False Positive)** # of relevant images that are not retrieved
	Negatives	**FN (False Negative)** # irrelevant images that are falsely retrieved	**TN (True Negative)** # of irrelevant images that are correctly not retrieved

Table 11 – Precision and Recall Definition

Use cases	Metric	Definition
Tattoo Similarity, Mixed Media, Tattoo Detection	Precision = The fraction of retrieved images that are truly relevant	$\frac{TP}{(TP + FP)}$
	Recall = The fraction of relevant images that are actually retrieved	$\frac{TP}{(TP + FN)}$

Note: NIST will consider both rank and threshold-based definitions of precision and recall.

9.2.1 Mean Average Precision (MAP)

The Average Precision is a single-valued measure that reflects the performance over all relevant images. It is the average of the precision value obtained after each relevant image is retrieved. (When a relevant image is not retrieved at all, its precision is assumed to be 0). The Mean Average Precision across the total number of probes is computed by taking the mean of the average precisions for each probe in the run.

9.2.2 Mean R-Precision

R-Precision is the precision after R images have been retrieved, where R is the number of relevant images for the probe. The average R-Precision across the total number of probes is computed by taking the mean of the R-Precisions for each probe in the run.

10. Ground truth integrity

The Tatt-C dataset ground-truth was established via manual relevance assessments created by human examiners following a specific protocol and may thus be subject to human bias. Every effort was made to ensure the data is correct for the specified intents of this challenge activity, but a small number of errors may still exist. Please report any suspected ground truth errors to tattoo@nist.gov.

11. Results submission to NIST

Output files should be archived with a utility such as tar or zip prior to submission. Participants can send their results and any other supporting documentation to NIST via email to tattoo@nist.gov or put the results onto electronic media (e.g., CD, USB drive) and send by mail to

Tatt-C Liaison
National Institute of Standards and Technology
Information Access Division (894)
100 Bureau Drive, Stop 8940
Gaithersburg, MD 20899-8940

A. Appendix A – ANSI/NIST-ITL 1-2011 Type 10 Field Codes

A.1 Tattoo Classes and Subclasses

Class Code	Subclass Description	Subclass Code
OBJECT	Fire	FIRE
	Weapons (Guns, Arrows, etc.)	WEAP
	Airplanes and other Air vehicles (incl. Blimps)	PLANE
	Boats, Ships, & Other Water Vessels	VESSEL
	Trains	TRAIN
	Cars, Trucks, and other Land Vehicles (except Trains)	VEHICLE
	Mythical (Unicorns, etc.)	MYTH
	Sporting Objects (Football, Ski, Hurdles, etc.)	SPORT
	Water & Nature Scenes (Rivers, Sky, Trees, etc.)	NATURE
	Miscellaneous Objects	MOBJECTS

Class Code	Subclass Description	Subclass Code
ABSTRACT	Figure(s)	FIGURE
	Sleeve	SLEEVE
	Bracelet	BRACE
	Anklet	ANKLET
	Necklace	NECKLC
	Shirt	SHIRT
	Body Band	BODBND
	Head Band	HEDBND
	Miscellaneous Abstract	MABSTRACT

Class Code	Subclass Description	Subclass Code
SYMBOL	National Symbols	NATION
	Political Symbols	POLITIC
	Military Symbols	MILITARY
	Fraternal Symbols	FRATERNAL
	Professional Symbols	PROFESS
	Gang Symbols	GANG
	Miscellaneous Symbols	MSYMBOLS

Class Code	Subclass Description	Subclass Code
OTHER	Wording (Mom, Dad, Mary, etc.)	WORDING
	Freeform Drawings	FREEFRM
	Miscellaneous Images	MISC

Class Code	Subclass Description	Subclass Code
HUMAN	Male Face	MFACE
	Female Face	FFACE
	Abstract Face	ABFACE
	Male Body	MBODY
	Female Body	FBODY
	Abstract Body	ABBODY
	Roles (Knight, Witch, man, etc.)	ROLES
	Sports Figures (Football Player, Skier, etc.)	SPORT
	Male Body Parts	MBPART
	Female Body Parts	FBPART
	Abstract Body Parts	ABBPART
	Miscellaneous Human Forms	MHUMAN
	Skulls	SKULL

Class Code	Subclass Description	Subclass Code
ANIMAL	Cats & Cat Heads	CAT
	Dogs & Dog Heads	DOG
	Other Domestic Animals	DOMESTIC
	Vicious Animals (Lions, etc.)	VICIOUS
	Horses (Donkeys, Mules, etc.)	HORSE
	Other Wild Animals	WILD
	Snakes	SNAKE
	Dragons	DRAGON
	Birds (Cardinal, Hawk, etc.)	BIRD
	Spiders, Bugs, and Insects	INSECT
	Abstract Animals	ABSTRACT
	Animal Parts	PARTS
	Miscellaneous Animal Forms	MANIMAL

Class Code	Subclass Description	Subclass Code
PLANT	Narcotics	NARCOTICS
	Red Flowers	REDFL
	Blue Flowers	BLUEFL
	Yellow Flowers	YELFL
	Drawings of Flowers	DRAW
	Rose	ROSE
	Tulip	TULIP
	Lily	LILY
	Misc. Plants, Flowers, Vegetables.	MPLANT

Class Code	Subclass Description	Subclass Code
FLAG	American Flag	USA
	State Flag	STATE
	Nazi Flag	NAZI
	Confederate Flag	CONFED
	British Flag	BRIT
	Miscellaneous Flags	MFLAG

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254 A.2 Tattoo Color Codes

Color Description	Color code
Black	BLACK
Brown	BROWN
Gray	GRAY
Blue	BLUE
Green	GREEN
Orange	ORANGE

Color Description	Color code
Purple	PURPLE
Red	RED
Yellow	YELLOW
White	WHITE
Multi-colored	MULTI
Outlined	OUTLINE

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B. Appendix B – National Crime Information Center (NCIC) Codes

B.1 NCIC SMT Body Location Codes

Item/Location	Code
Abdomen	TAT ABDOM
Ankle, left	TAT L ANKL
Ankle, nonspecific	TAT ANKL
Ankle, right	TAT R ANKL
Arm, left	TAT L ARM
Arm, left upper	TAT UL ARM
Arm, nonspecific	TAT ARM
Arm, right	TAT R ARM
Arm, right upper	TAT UR ARM
Back	TAT BACK
Breast, left	TAT L BRST
Breast, nonspecific	TAT BREAST
Breast, right	TAT R BRST
Buttock, left	TAT L BUTK
Buttock, right	TAT R BUTK
Buttocks, nonspecific	TAT BUTTK
Calf, left	TAT L CALF
Calf, nonspecific	TAT CALF
Calf, right	TAT R CALF
Cheek (face), left	TAT L CHK
Cheek (face), nonspecific	TAT CHEEK
Cheek (face), right	TAT R CHK
Chest	TAT CHEST
Chin	TAT CHIN
Ear, left	TAT L EAR
Ear, nonspecific	TAT EAR
Ear, right	TAT R EAR
Elbow, left	TAT LELBOW
Elbow, nonspecific	TAT ELBOW
Elbow, right	TAT RELBOW
Eye, left	TAT L EYE
Eye, nonspecific	TAT EYE
Eye, right	TAT R EYE
Face, nonspecific	TAT FACE
Finger(s), left hand	TAT L FGR
Finger(s), right hand	TAT R FGR
Finger, nonspecific	TAT FNGR
Foot, left	TAT L FOOT
Foot, nonspecific	TAT FOOT
Foot, right	TAT R FOOT
Forearm, left	TAT LF ARM
Forearm, nonspecific	TAT FARM
Forearm, right	TAT RF ARM
Forehead	TAT FHD
Full body (used when arms, legs, chest, and back are covered with tattoos)	TAT FLBODY
Groin area	TAT GROIN
Hand, left	TAT L HND
Hand, nonspecific	TAT HAND
Hand, right	TAT R HND
Head, nonspecific (use the MIS Field to further describe location)	TAT HEAD
Hip, left	TAT L HIP
Hip, nonspecific	TAT HIP
Hip, right	TAT R HIP
Knee, left	TAT L KNEE
Knee, nonspecific	TAT KNEE
Knee, right	TAT R KNEE
Leg, left	TAT L LEG
Leg, nonspecific	TAT LEG
Leg, right	TAT R LEG
Lip, lower	TAT LW LIP
Lip, nonspecific	TAT LIP
Lip, upper	TAT UP LIP
Neck	TAT NECK
Nose	TAT NOSE
Penis	TAT PENIS
Shoulder, left	TAT L SHLD
Shoulder, nonspecific	TAT SHLD
Shoulder, right	TAT R SHLD
Thigh, left	TAT L THGH
Thigh, nonspecific	TAT THGH
Thigh, right	TAT R THGH
Wrist, left	TAT L WRS
Wrist, nonspecific	TAT WRS
Wrist, right	TAT R WRS